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THE RED OAK - WHITE OAK FORESTS OF THE ANTHRACITE REGION

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FOREWORD

Research work in forest management and fire protection in the Anthracite Region of Pennsylvania was started in 1945 by the Station's branch at Kingston, Pa. This is one of a series of progress reports on the work completed to date.

This paper presents general information, research findings, and recommendations for applying good forest-management practices to one of the major forest types of the region. The findings presented here are tentative; further work will undoubtedly bring to light additional facts that will help to produce more conclusive results.

The authors make acknowledgment to the Pennsylvania Department of Forests and Waters for permission to re-measure six growth plots located in the Anthracite Region, and for the use of data gathered on these plots in the past. They also thank the many landowners on whose property the sample plots were established; the personnel of the Industrial Forestry Division of the Wyoming Valley Chamber of Commerce, for their advice and assistance; and the many other individuals who have shown an interest and desire to help solve the many forest problems found in the Anthracite Region.

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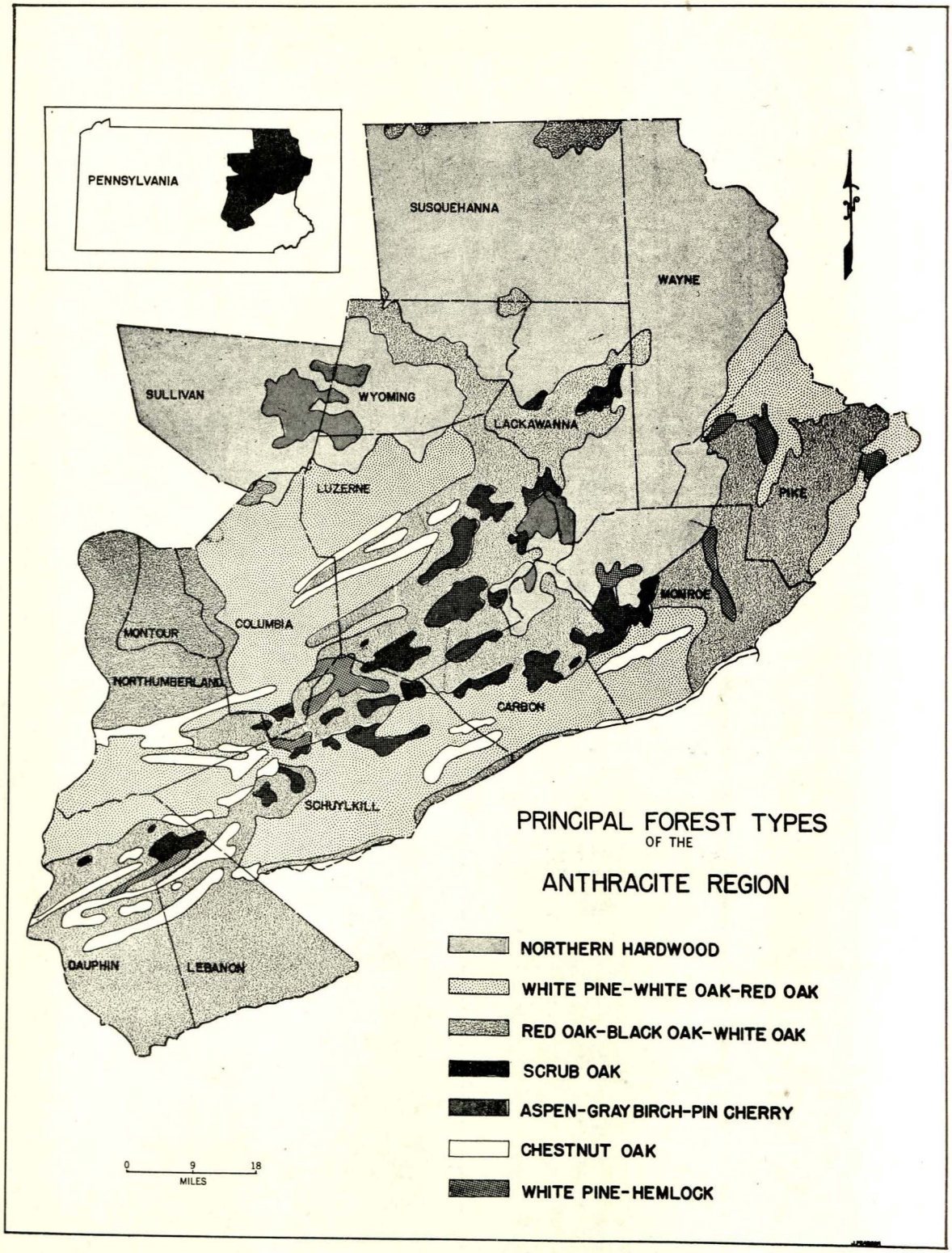
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THE RED OAK -- WHITE OAK FORESTS 1/ OF THE ANTHRACITE REGION

Their Present Condition and Possible Treatment

by C. F. Burnham
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INTRODUCTION

The red oak - white oak forests of the Anthracite Region occupy a substantial portion--28.6 percent or 915,200 acres--of the region's 3,198,400 acres of forest land. These forests have been so heavily cut for lumber and mine timbers during the past 100 years and have been so badly ravaged by fire following these heavy cuttings that in their present condition they are a poor asset to the region.

Only 2.8 percent or 26,000 acres can be classified as saw-timber area, that is, an area on which enough trees of saw-timber size can be found to justify a logging operation. Two thousand board feet per acre is generally considered the minimum quantity necessary to warrant cutting for sawlogs. In contrast to this, 97.2 percent or 889,200 acres fall in the category of pole-timber and sapling areas. This acreage is covered with timber too small to make sawlogs, or does not contain the 2,000 board feet per acre mentioned above.

In resources, land use, land ownership, and industry the Anthracite Region divides naturally into three economic subregions 2/: the coal fields, the farming areas, and the extensive forests. Each subregion differs greatly from the others; each subregion has its own characteristic problems...The most important difference among the three subregions is the type of ownership that dominates each. In the coal fields almost two-thirds of the forest land belongs to the coal companies...Most of the forest in the farming area is in small tracts and belongs either to farmers or to other private owners...The extensive forest area is in relatively large tracts; about a third of it is publicly owned.

1/ Equivalent to the red oak - black oak - white oak type of the SAF forest-type classification.

2/ Ineson, F. A., Ferree, M. J., and Robinson, D. F. The Anthracite Forest Region--A Problem Area. 1946. (In process of publication by U. S. Dept. Agr.)

The largest part of the red oak - white oak forests is in the extensive forest subregion (42.1 percent) and in the farm areas (38.1 percent). Woodlands in these two subregions, while heavily cut and burned in the past, have not been subjected to the abusive cutting and devastating fires prevalent in the coal field area. Only 19.8 percent of this forest type is found in proximity to the coal fields.

Table 1.--Acreage and volume distribution of the red oak - white oak type, by stand-size classes[1/]

Item	Saw timber	Pole timber	Unmerchantable[2/] (Seedling & sapling)	All stands
Acres	26,000	122,800	766,400	915,200
Percent	2.8	13.4	83.8	100
Sawlog material				
Thousand bd.ft.	108,900	103,500	236,100	448,500
Percent	24.3	23.1	52.6	100
Thousand bd.ft. per acre	4.20	0.84	0.31	0.49
Other material:				
Tons	793,700	1,936,300	4,743,300	7,473,300
Percent	10.6	25.9	63.5	100
Tons per acre	30.5	15.8	6.2	8.2
All material:				
Thousand cu.ft.	40,810	78,690	189,040	308,540
Percent	13.2	25.5	61.3	100
Thousand cu.ft. per acre	1.50	0.64	0.25	0.34

1/ Ineson, F. A., Ferree, M. J., and Robinson, D. F. The Anthracite Forest Region--A Problem Area. 1946. (In process of publication.) Northeastern Forest Experiment Station. Table data are for the entire 15-county area. The percentages and volume-per-acre figures should not be confused or compared with the actual plot figures which follow.

2/ Includes tracts of saw timber and pole timber less than 10 acres in size. The classification "seedling and sapling" used elsewhere in this paper does not include these tracts.

Volume figures (table 1) show that the red oak - white oak forests are relatively insignificant in their volume of sawlog material. Yet, this valuable forest type, which is the second largest in the region, should be one of the region's major sources of high-quality lumber. It can be if present cutting practices are greatly improved and if fires are eliminated.

This paper sets forth the present conditions of these forest stands, and suggests silvicultural treatments that will result in greater productivity within a relatively short time. These suggested treatments are based on the best information available at present, but are subject to revision and greater refinement as further research brings additional factors to light and makes more definite conclusions possible.

METHODS USED IN THE STUDY

The red oak - white oak areas studied were classified into three sites and, within each site, three stand-size classes. Five representative sample plots were then measured in each category, and detailed information was collected on each plot. No samples were taken on site III, as it occupies a very limited acreage in the red oak - white oak type.

Thirty widely-distributed sample plots were selected in the counties of Luzerne, Columbia, and Monroe. In the saw-timber and pole-timber stands sample plots were varied in size from 0.2 acre to 0.75 acre in order to include a minimum of 75 living trees 3.6 inches d.b.h. and larger on each plot. In the seedling-and-sapling stands each sample plot was 0.1 acre in size. In addition to these sample plots, four permanent-growth plots established in Luzerne County in 1906 by the Pennsylvania Department of Forests and Waters were re-measured, and the information was used to check and supplement the data taken on the other plots.

For each plot was recorded: exact location of the plot; ownership; forest type; forest site; stand-size class; age of stand; herbaceous material on the forest floor; amount and kind of trees 0.1-3.5 inches d.b.h.; estimate of reproduction; history of tract as to grazing, fire and past cutting; general soil type; and an estimate of the amount of natural mortality in the past 10 years. For each live tree 3.6 inches d.b.h. and larger, the species, d.b.h., vigor class, estimated percentage of cull, origin (seedling or sprout), tree form (good or poor), and the past 10-year radial growth as determined from an increment core were recorded. Also, each plot was marked for cutting in accordance with what was considered the most practical silvicultural treatment.

In order to simplify analyses for sites and stand-size classes the sample plot data were summarized on a plot basis and an average summary made for the five plots in each category. In this manner it was possible to make an appraisal of the present condition for each plot and also for the average of each five-plot unit. In addition, the annual growth rates for each site were correlated with volume-per-acre of growing stock. The volumes-per-acre (table 2) do not necessarily reflect the average volume-per-acre figures for the Anthracite Region (table 1). In selecting the plots in the field an attempt was made to get a range in volume in each stand-size class from the lowest to the highest so that in making growth determinations this range in volume-per-acre classes would be represented.

PRESENT CONDITION

The red oak - white oak stands on site I are quite similar to those on site II (table 2). They are young and even-aged, as a result of very heavy cutting during the past century and of fires which often followed the logging operations.

The low volumes, light stocking, and the high percentage of poorly-formed trees and trees of sprout origin on both sites are due to the misuse these stands have suffered in the past. In volume, white oak, red oak and red maple predominate; black oak, chestnut oak, and hemlock rank second. A large number of other species--principally yellow poplar, white ash, black birch, sassafras, and aspen--appear as minor associates.

Although reproduction is ample where grazing does not occur, non-commercial species such as shadbush, witch hazel, gray birch, ironwood, and blue beech are most numerous. Of the commercial species red maple is most abundant.

Wider spacing and relative freedom from competition between trees above 5.5 inches d.b.h. makes the seedling-and-sapling stands appear to be more vigorous than either of the other two stand-size classes.

Cull volume, as might be expected, is highest in the saw-timber stands. Fire-damaged trees and defective hold-overs account for most of it, especially on site II where these trees are more prevalent. About 80 percent of the cull volume on both sites is in red oak, white oak, and red maple.

Mortality is fairly low. Of all the stems that die naturally, over 86 percent are in the 1-to 3-inch diameter classes. Non-commercial species, red maple, and to a lesser extent white oak, constitute most of it.

Table 2.--Summary of conditions on typical red oak - white oak stands studied

Average condition	Saw timber		Pole timber		Seedling and sapling	
	Site I	Site II	Site I	Site II	Site I	Site II
Volume per acre .... Cubic feet..	2,363	2,061	1,315	1,026	401	209
Tons..	72	62	40	31	12	6
Board feet..	7,544	6,162	1,330	369	--	--
Average age ..... Years..	70	85	50	63	30	37
Trees per acre						
Pole size (3.6" d.b.h.) and larger ..... Number..	236	232	308	358	316	180
Seedling and sapling (0.6-3.5" d.b.h.) ... Number..	638	891	848	1,009	3,762*	3,286*
Reproduction ..... Degree.. (under 4.5' high)	Ample	Ample	Ample	Ample	Ample	Moderate
Quality ..... Percent of total cu.-ft. volume in poorly formed trees..	29.8	32.6	36.6	38.0	45.5	53.8
Origin ..... Percent of total cu.-ft. volume in sprout-origin trees..	13.5	17.5	23.9	31.8	40.6	45.5
Vigor[1] ..... Percent in vigor class 1..	13.9	14.2	12.8	11.4	17.5	31.0
vigor class 2..	25.8	20.1	23.2	32.0	39.6	20.2
vigor class 3..	38.6	46.8	38.8	42.4	32.8	41.3
vigor class 4..	21.7	18.9	25.2	14.2	10.1	7.5
Cull ..... Percent of total cu.-ft. volume..	5.4	10.1	3.8	2.6	3.7	3.3
of total bd.-ft. volume..	4.3	14.7	2.6	0.3	--	--
Annual mortality ... Cubic feet per acre..	3.1	2.3	4.3	6.2	0.1	0
Percent of total growth..	4.5	4.3	7.5	13.0	0.3	--
Annual growth[2] per acre .... Cubic feet..	67.0	55.0	53.0	40.0	30.0	18.0
Tons..	1.9	1.6	1.6	1.1	0.8	0.5
Board feet..	289.0	212.0	48.0	25.0	--	--
Ingrowth ..... Percent of annual cu.-ft. increase..	2.8	2.4	9.2	8.2	59.6	36.8
of annual bd.-ft. increase..	39.3	43.1	75.7	92.0	--	--

1/ For definitions see appendix.
2/ Mortality deducted.
* Figures include trees down to 0.1 inch d.b.h.

Growth rates are moderate. As annual growth is dependent on the volume of growing stock, the high-volume plots show the greatest annual increase (5).3/ Table 3 shows the current annual growth that may be expected under natural growing conditions for different stand volumes after deducting for mortality. These figures in general conform quite closely to the growth rates determined by McIntyre (7).

Table 3.--Growth in untreated red oak - white oak stands1/

Growing stock per acre2/	Annual growth per acre		Growing stock per acre2/	Annual growth per acre		Growing stock per acre3/	Annual growth per acre	
	Site I	Site II		Site I	Site II		Site I	Site II
Cubic feet	Cubic feet	Cubic feet	Tons	Tons	Tons	Board feet	Board feet	Board feet
200	22	18	6.1	0.6	0.5	1,000	85	65
400	30	25	12.1	.8	.7	2,000	145	110
600	36	31	18.2	1.0	.9	3,000	195	147
800	42	36	24.2	1.2	1.0	4,000	230	177
1,000	47	40	30.3	1.3	1.1	5,000	257	200
1,200	51	44	36.4	1.4	1.2	6,000	274	212
1,400	55	47	42.4	1.5	1.3	7,000	285	220
1,600	58	50	48.5	1.6	1.4	8,000	293	224
1,800	61	52	54.5	1.7	1.5	9,000	297	227
2,000	64	54	60.6	1.8	1.5	10,000	299	229
2,200	66	55	66.7	1.9	1.6	--	--	--
2,400	68	56	72.7	1.9	1.6	--	--	--
2,600	70	57	78.8	2.0	1.6	--	--	--
2,800	72	58	84.8	2.0	1.7	--	--	--
3,000	73	59	90.9	2.1	1.7	--	--	--

1/ Mortality deducted.
2/ In trees 3.5 inches d.b.h. and over.
3/ In trees 11 inches d.b.h. and over.
Converting factor: 33 cubic feet = 1 ton.

SILVICULTURAL TREATMENTS

A few fundamental characteristics of the species involved should be borne in mind in considering possible forest management practices for this type:

1. The principal species are prolific sprouters.

2. The oaks bear heavy seeds. They rely on gravity for dispersal. Rodents and insect larvae destroy a large part of them(4). The red oaks start to bear seed annually at about 30 years of age, with heavy seed years at 2- to 3-year intervals. The white oaks start to bear seeds at about 50 years of age with heavy seed years at 3- to 6-year intervals.

3. Red maple bears light, wind-dispersed seed annually, starting at an early age.

4. The principal species will endure only a moderate amount of shade.

5. Oaks need ample crown space to grow vigorously.

6. The present stands are even-aged.

The outstanding difference between stands on sites I and II is the rate of growth. In marking the saw-timber stands it was found that nearly 75 percent of the board-foot volume on site I and about 50 percent of the board-foot volume on site II is in low-quality trees and should be removed. In both cases this volume is composed of red oak, white oak, and red maple. The present excellent market for all forest products offers a good opportunity to remove this material at a profit.

Work done by Spaeth(9) in Dutchess County, New York, on particularly good oak sites, and information obtained from a series of four growth plots maintained by the Pennsylvania Department of Forests and Waters on the Oliver Estate in Luzerne County on a fair oak site show that growth rates increase when stands are partially cut. The rates of increment obtained in these two instances were the bases for increasing the natural growth rates (table 3) by 10 percent on site I and 8 percent on site II in projecting the residual stands (tables 4-5).

SAW-TIMBER STANDS

Since the major species will endure only a moderate amount of shade, and since these stands are relatively even-aged, some form of even-aged management is desirable. A method of partial cutting which allows seedlings to become established under a light overstory is recommended. This is known as the shelterwood system. Reproduction by sprouting should be discouraged(8). However, the saw-timber stands studied are in very poor condition. Before any form of managed harvest cutting can be attempted, improvement cuts are needed.

The saw-timber stands shown in tables 6-9 have been used in compiling tables 4 and 5 respectively to indicate what may be expected when improvement cuttings of various intensities are employed. These same stands were marked for removal in the field for calculating purposes. No actual cutting was done. The stems marked were in most cases mature, of poor form, inferior species, or showed signs of decay. Computation of the volume contained in the trees so marked showed 5,500 board feet (37 tons) on site I and 3,800 board feet (22 tons) on site II of this low-quality material that should be removed. Cuttings aimed at improving the composition and quality of the stand are fully as important as those aimed primarily at obtaining reproduction. Several methods may be used to remove the low-quality trees marked for cutting.

The heavy cut.--Use of this method would complete the improvement work in one operation. The initial heavy cut would have a two-fold purpose. It would remove all the low-quality material from the stand, and it would stimulate seedling reproduction of the favored species. Spaeth (9) found that heavy improvement cuts serve as seed cuts. Forty years after the initial cut on site I and 30 years after on site II, when the stands have attained volumes of 12,000 and 10,000 board feet per acre respectively, another cut should be made to remove 50 percent of the board-foot volume. In making this second or seed cut care should be exercised to leave large, well spaced, seed-bearing trees of high-quality species, especially the heavy-seeded oaks. These are needed to ensure reproduction, and to afford protection to the areas while the seedlings are becoming established. Ten years later the seed trees should be removed as a final cut. This will leave a resulting stand of desirable reproduction plus well distributed trees which became established after the first cut. This method of cutting is suitable for extensive forests where large volume is required to meet high logging costs.

The moderate cut.--This system would remove the low-quality material in two operations. In the site I stand (table 4) 3,000 board feet (19 tons) per acre would be removed immediately and an equal amount 15 years later. After 20 years, a volume of 12,000 board feet per acre will be reached; and the seed and final cuts should be made as described in the preceding paragraph. In the site II stand (table 5) less volume would be removed in each cutting than in site I. Half of the low-quality material (1,400 board feet or 11 tons per acre) should

Figure 1.--Saw timber, site I.

be taken out by the first cut and 1,900 board feet or 15 tons 10 years later. After 20 years, when the stand has attained 10,000 board feet per acre, the succeeding seed and final cuts should be made. This method of cutting should be profitable on either farm forests or extensive forests, wherever logging costs do not demand a large volume. It provides financial returns at relatively short intervals while conditioning the stand for the final harvest and assuring adequate reproduction of desirable species.

The light cut.--This method is suggested for farm woodland owners who desire yields from their woodlands frequently, and who can find time to do their own woods work during months when farming work is slack. Tarver and Mitchell (10) discovered that 75 percent of the total value of hardwood logs and 95 percent of the total value of fuelwood is in wages and business profit. Most of this extra value can be realized by the landowner who

Figure 2.--Saw timber, site II.

does his own logging and sells wood products rather than stumpage. The light-cut system allows small removals at 5-year intervals. In the site I stand each of the first two cuts would be 800 board feet per acre and each of the next four 1,000 board feet per acre. This would remove most of the low-quality material and at the same time allow the growing stock to build up to 12,000 board feet per acre in 30 years. In the site II stand the improvement work would be completed and the growing stock built up to 10,000 board feet per acre by making six light cuts; the first three removing 500 board feet each, the next two removing 600 board feet each, and the sixth cutting 700 board feet. By properly prorating these periodic cuts over an entire farm woodland it would be possible for an owner to sustain annual employment. The seed and final cuts should be applied when the stands have reached 12,000 and 10,000 board feet per acre on sites I and II respectively. This method offers frequent financial returns and higher-quality lumber.4/ However, its application may cause considerable damage to the remaining trees unless the logging operations are carefully conducted.

4/ Lake States Forest Experiment Station. Light cuttings in hardwoods show high quality increment. Lake States Forest Expt. Sta. Tech. Note No. 166. 1940.

One thousand board feet per acre is left after making the final cut in each case. It will require 30 years for this to build up to 8,000 board feet on site I and 6,000 board feet on site II, at which time the same methods can be repeated. During this period light improvement cuts should be made to reduce the proportion of undesirable species where they persist. The second rotation should produce material of high quality, and consequently yield higher financial returns. The method of cutting can be changed as desired, provided sufficient time is allowed for growth. Because of the longevity of the oak species, particularly white oak, it may be possible to increase the volume per acre of mature stands by postponing the final cut, after the present stands have been put into good condition.

Clear-cutting.--The present practice of cutting all trees down to 2 inches d.b.h. is undesirable, and its use should be discontinued. It yields considerably less volume over a given number of years and a greater proportion of low-quality material than any of the partial-cutting methods(6). Clear-cutting hampers growing conditions for future stands in several ways:

1. The site is exposed so that soil erosion and soil drying-out is severe.

2. The fire hazard is increased because of the large amounts of slash left after logging.

3. Sprout reproduction is encouraged.

4. The proportion of red maple and light-seeded non-commercial species will increase.

5. Dense briar growth often occupies the clear-cut site and retards the establishment of good species for many years.

6. It favors the establishment of gypsy moth and other destructive insect pests.5/

It is interesting to note (tables 4 and 5) that the amount of material removed over a long period of time is significantly greater when the stands are partially cut under the shelterwood system. Clear-cutting produces a much smaller yield. Then, too, the degrees of cutting under the shelterwood system also produce different yields. The lightest cut, while producing about the same yield as the heaviest, does so in a shorter period of time. This is particularly true on the better sites.

5/ Spurr, S. H., Littlefield, E. W., and Bess. H. A. Relation of forest site condition to gypsy moth abundance and forest practices which develop resistance to gypsy moth. 1946. (Unpublished manuscript, Harvard Forest.)

Table 4.—Comparison of four methods of removing low-quality material from the red oak - white oak stands, site 1 [1]

Year	Item	Clear cut [2]	Heavy cut	Moderate cut	light cut
		Board feet	Board feet	Board feet	Board feet
1946	Present volume	7,700	7,700	7,700	7,700
	Amount removed	7,700	5,500	3,000	800
	Remainder	0	2,200	4,700	6,900
1951	Expected volume	—	—	—	8,500
	To be removed	—	—	—	800
	Remainder	—	—	—	7,700
1956	Expected volume	—	—	—	9,300
	To be removed	—	—	—	1,000
	Remainder	—	—	—	8,300
1961	Expected volume	—	—	9,000	9,900
	To be removed	—	—	3,000	1,000
	Remainder	—	—	6,000	8,900
1966	Expected volume	—	—	—	10,600
	To be removed	—	—	—	1,000
	Remainder	—	—	—	9,600
1971	Expected volume	—	—	—	11,300
	To be removed	—	—	—	1,000
	Remainder	—	—	—	10,300
1976	Expected volume	—	—	—	12,000
	To be removed	—	—	—	6,000
	Remainder	—	—	—	6,000
1981	Expected volume	—	—	12,000	—
	To be removed	—	—	6,000	—
	Remainder	—	—	6,000	—
1986	Expected volume	—	12,000	—	9,300
	To be removed	—	6,000	—	8,300
	Remainder	—	6,000	—	1,000
1991	Expected volume	—	—	9,300	—
	To be removed	—	—	8,300	—
	Remainder	—	—	1,000	—
1996	Expected volume	1,500	9,300	—	—
	Removal	—	8,300	—	—
	Remainder	—	1,000	—	—
	Total volume removed	7,700	19,800	[3] 20,300	[4] 19,900

[1] Growth rates shown in table 3 were used. They were increased by 10 percent when applied to the stands after cutting.
[2] Removes all stems to 2-inch d.b.h.
[3] Material removed in 45 years.
[4] Material removed in 40 years.

Table 5.—Comparison of four methods of removing low-quality material from the red oak - white oak stands, site II[1]

Year	Item	Clear cut[2]	Heavy cut	Moderate cut	Light cut
		Board feet	Board feet	Board feet	Board feet
1946	Present volume	6,300	6,300	6,300	6,300
	Amount removed	6,300	2,800	1,400	500
	Remainder	0	3,500	4,900	5,800
1951	Expected volume	—	—	—	6,900
	To be removed	—	—	—	500
	Remainder	—	—	—	6,400
1956	Expected volume	—	—	7,100	7,600
	To be removed	—	—	1,900	500
	Remainder	—	—	5,200	7,100
1961	Expected volume	—	—	—	8,300
	To be removed	—	—	—	600
	Remainder	—	—	—	7,700
1966	Expected volume	—	—	—	8,900
	To be removed	—	—	—	600
	Remainder	—	—	—	8,300
1971	Expected volume	—	—	—	9,500
	To be removed	—	—	—	700
	Remainder	—	—	—	8,800
1976	Expected volume	—	10,000	10,000	10,000
	To be removed	—	5,000	5,000	5,000
	Remainder	—	5,000	5,000	5,000
1981	Expected volume	—	—	—	—
	To be removed	—	—	—	—
	Remainder	—	—	—	—
1986	Expected volume	500	7,300	7,300	7,300
	To be removed	—	6,300	6,300	6,300
	Remainder	—	1,000	1,000	1,000
	Total volume removed	6,300	14,100	14,600	14,700

1/ Growth rates shown in table 3 were used. They were increased by 8 percent when applied to the stands after cutting.

2/ Removes all stems to 2-inch d.b.h.

Figure 3.--Pole timber, site I.

Figure 4.--Pole timber, site II.

POLE-TIMBER STANDS

In marking the pole-timber stands, (tables 10-13) it was found that there are 190 cubic feet (6 tons) per acre of low-quality material on site I and 116 cubic feet (3.5 tons) per acre on site II. The bulk of it is in deformed or defective white oak, red oak, and red maple trees, some of which are large, slow-growing hold-overs from previous cutting operations. All this material should be removed now in order to improve the stands so that high-quality stems will constitute the ultimate saw-timber volume. A profit could be made from the sale of the cut trees for mine timbers. Where the large hold-over trees are so highly defective that financial returns would not defray the logging costs, where the damage caused in felling would exceed their value, and where they are obviously retarding the growth of valuable trees they could be eliminated by girdling. Such stand-improvement work would not only better the composition, but it would also increase the growth rate on the crop trees. Buell (2) found that 5 years after a thinning and girdling operation in Appalachian hardwoods the crop trees showed 54 percent greater diameter growth than for the 5 years before cutting.

SEEDLING-AND-SAPLING STANDS

The stand data for the seedling-and-sapling plots show a large number of non-commercial species on both sites (tables 14-17). A high proportion of volume on these plots is in trees of poor form and sprout origin (table 2). The condition of these stands can be improved by reducing the number of non-commercial species and the volume contained in trees of poor form and sprout origin. The most favorable time to reduce sprout clumps is before the stands attain pole-timber size (8). Buell (1) discovered that if the cutting is done during the summer months the crop trees will suffer the least sprout competition because stump sprouting is at a minimum during that season of the year. This treatment is needed on site I where there are 4,000 stems per acre with large numbers of red maple, shadbush, witch hazel, thorn apple, etc. (tables 14, 15). Approximately 8 man-hours per acre would be required to do this work when no attempt is made to salvage any of the material(3). The site II seedling and sapling stands, although they contain many undesirable stems, are sparsely stocked and warrant improvement work only in rare cases. Most cuttings of this nature will require a direct monetary outlay with no immediate returns. However, in some of the higher-volume seedling and sapling stands on either site it may be possible to utilize some of the material as mine lagging, which will help defray the costs of the operation. Where stocking warrants, such cuttings will improve the quality of the stands so that increased dividends will be realized ultimately.

Figure 5.--Seedling-and-sapling stand, site I.

Figure 6.--Seedling-and-sapling stand, site II.

General

Protection from fire and grazing is essential in any form of forest management.

Planting is not necessary in the oak forests, since natural reproduction will be satisfactory if the proper silvicultural treatments are employed. Emphasis should be placed on encouraging natural regeneration of forest stands rather than on planting.

These management practices will be beneficial to the maintenance of wildlife, since there will be no clear-cut areas where sites are exposed to erosion and forest fires, and a constant overstory of trees is assured.

If these forest management practices are followed, the red oak-white oak forests will contribute considerably to the economy of the Anthracite Region. It will be possible to increase the present annual yield by at least 20 times and to improve greatly the quality of the products.

LITERATURE CITED

(1) Buell, J. H.
1940. Effect of season of cutting on sprouting of dogwood. Jour. Forestry 38: 376-378.

(2) _____
1943. Results of C.C.C. timber stand improvement on Southern Appalachian national forests. Jour. Forestry 41: 105-112.

(3) Cline, A. C.
1935. Improvement cutting and thinning as applied to Central New England hardwoods. Mass. Forest and Park Assoc. Bul. No. 155, 16 pp., illus.

(4) Downs, A. A., and McQuilkin, W. E.
1944. Seed production of Southern Appalachian oaks. Jour. Forestry 42: 913-920.

(5) Hough, A. F.
1943. Methods of harvesting sawtimber from forests in the high plateaus section of Pennsylvania. Jour. Forestry 41: 898-903, illus.

(6) Matthews, D. M.
1939. Comments on sustained yield versus clear-cutting. Jour. Forestry 37: 222-224.

(7) McIntyre, A. C.
1933. Growth and yield in red oak forests of Pennsylvania. Pa. Agr. Expt. Sta. Bul. No. 283.

(8) Roth, Elmer R., and Sleeth, Baily.
1939. Butt rot in unburned sprout oak stands. U. S. Dept. Agr. Tech. Bul. No. 684, 43 pp., illus.

(9) Spaeth, J. N.
1927. Twenty years growth of a sprout hardwood forest in New York: a study of the effects of intermediate and reproduction cuttings. Cornell Univ. Agr. Expt. Sta. Bul. 465.

(10) Tarver, C. L., and Mitchell, H. C.
1941. It pays to sell timber products, not stumpage. U. S. Soil Conserv. Serv. publication. Fort Worth, Texas.

APPENDIX

DEFINITIONS OF TERMS

Specific application of terms used in this paper is in accord with the definitions given below.

Forest Sites

Site I.--This site is characterized by moist, well-drained, fairly deep soils frequently of alluvial origin. It usually is found in protected coves or along streams or bottom-lands that maintain moist, well-drained conditions throughout the year. On northern exposures it ordinarily extends higher up the slope than on southern exposures because of more favorable soil moisture. Club moss, hydrangea, maidenhair fern, trillium, sphagnum moss, and fern-leaf moss are fairly good indicators.

Hemlock and yellow poplar often appear in mixture with the oaks and red maple on this site. In mature stands the dominant and co-dominant hardwood species will produce three or more 16-foot logs per tree. Conifer dominants and co-dominants will produce $3\frac{1}{2}$ or more 16-foot logs.

Site II.--Site II areas are characterized by soils intermediate in moisture, depth, drainage, and fertility. They will dry out for only short periods during the year. Usually they are slope types located between the ridges and the coves or bottom-lands. Poorly drained bottom-lands may be of site II quality. Ordinarily the site will reach nearly to the ridge tops. It will reach higher on slopes with northern exposures than on slopes with southern exposures. Trailing arbutus, ground pine, aster, goldenrod, bracken fern, and sheep laurel usually indicate site II.

Red oak, white oak, and red maple are the predominant species. Associated species consisting of chestnut oak, scarlet oak, black oak, sassafras, or American chestnut usually indicate a site II condition. In mature stands the dominant and co-dominant hardwood species will produce from 2 to $2\frac{1}{2}$ 16-foot logs per tree, while the conifers will yield $2\frac{1}{2}$ to 3 16-foot logs.

Site III.--This site is characterized by shallow, rather dry, stony, or compact soils characteristic of ridges. It will produce hardwood trees having less than two 16-foot logs per tree at maturity. On southern exposures it may extend down a slope for a considerable distance, because of unfavorable soil moisture conditions. Dense mountain laurel ground cover or preponderance of lichens often indicate site III conditions.

Forest Stand-Size Classes

Saw-timber stands.--Stands bearing a minimum volume of 2,000 board feet per acre. Saw-timber volume is measured in conifers in the 9-inch d.b.h. class and over, and in hardwoods in the 11-inch d.b.h. class and over.

Pole-timber stands.--Stands bearing a minimum volume of 5 standard cords per acre in trees in the 4-inch d.b.h. class and over, and less than 2,000 board feet of saw timber.

Seedling-and-sapling.--Young growth areas of forest land which have less than 5 standard cords of wood per acre in trees in the 4-inch d.b.h. class and over.

Tree Vigor Classifications

In this study tree vigor is an expression of the present growth rate of a tree as conditioned by desnity, size, and position of the crown, plus the general health of the tree as determined from its age and the presence or absence of diseases or mechanical injuries. Four vigor classes are recognized. Trees in these classes meet the following conditions.

Vigor Class 1.--These trees have large dense crowns, are usually dominant or co-dominant with at least one-half of their crowns exposed, are free from diseases or mechanical breakage tending to reduce the crown surface, (small mechanical injuries on tree trunks do not affect the vigor classification). They are free from old-age stagnation as evidenced by dead limbs in the crown, and have a general healthy and thrifty appearance.

Vigor class 2.--These trees have fair-sized crowns with moderate density or large crowns of light density, are usually co-dominant with less than one-half the crown exposed, but with more than the tip in the open in well stocked uncut stands. They are free from diseases or mechanical breakage tending to reduce the crown surface, and are free from old-age stagnation. This class may include trees that are dropped from vigor class 1 because of injury, disease or old age.

Vigor class 3.--These trees have small, dense crowns with just the tips exposed and are free from diseases and mechanical injuries tending to reduce crown surface. They have not reached old-age stagnation. This class may include trees that are dropped from vigor classes 1 or 2 because of injury, disease, or odl age.

Vigor class 4.--These trees are growing under obvious handicaps, such as severe suppression, injury, disease, or old age.

Tree Origin

Seedling.--Any tree which at present shows no union with a stump or other tree and can be silviculturally treated as a single tree.

Sprout.--Any tree which is joined to a stump, other tree, or clump of trees.

Tree Form

Good form.--Any tree which at present has a clear, straight bole and is a potential saw-timber tree.

Poor form.--Any tree which at present is so deformed that its potential use would not exceed that of a mine prop.

Other Terms

Ingrowth.--Volume of small-sized trees that have grown into the merchantable classes during the past 10 years.

Mortality.--Number and/or volume of trees which have been lost through natural causes such as insects, disease, windfall, or suppression during the past 10 years.

Table 6.—Average stand data, site I, saw-timber class: number of stems per acre, by species and diameter

D.b.h. (Inches)	Hemlock	White oak	Red oak	Chestnut oak	Black oak	White ash	Red maple	Black birch	Hickory	Misc.1/	Total	Percent
1	16	24	41	—	—	13	121	—	8	286	509	79.8
2	—	—	12	—	—	—	56	—	—	16	84	13.2
3	8	—	—	—	—	13	16	—	—	8	45	7.0
Total	24	24	53	—	—	26	193	—	8	310	638	100.0
Percent	3.8	3.8	8.3	—	—	4.1	30.2	—	1.2	48.6	100.0	—
4	5.3	2.1	3.8	1.6	—	0.6	18.8	1.5	0.8	14.0	48.5	20.6
5	8.0	1.1	—	2.4	—	1.6	8.2	4.8	.3	2.8	29.2	12.4
6	2.4	2.7	2.2	0.8	0.8	1.6	11.4	3.2	1.9	1.7	28.7	12.2
7	.8	3.0	.9	—	.8	.8	9.9	.8	.6	1.1	18.7	7.9
8	1.6	2.2	1.6	.8	—	.3	6.3	3.5	—	.3	16.6	7.0
9	.8	6.0	3.9	1.4	—	.8	4.4	1.9	—	.8	20.0	8.5
10	—	4.6	1.9	.8	.8	—	3.1	—	.6	—	11.8	5.0
11	.8	7.5	2.2	.8	1.6	—	4.7	.8	—	—	18.4	7.8
12	—	3.3	2.8	.8	—	—	3.0	—	—	—	9.9	4.2
13	0.6	6.0	3.9	—	—	—	.8	—	—	—	11.3	4.8
14	1.1	2.7	1.9	—	—	—	2.2	—	—	—	7.9	3.3
15	—	1.6	2.4	—	—	—	—	—	—	—	4.0	1.7
16	—	.3	1.3	—	—	.3	—	—	—	—	1.9	.8
17	—	—	1.9	—	.8	—	—	—	1.6	.8	5.1	2.2
18	—	—	1.4	—	—	—	—	—	—	—	1.4	.6
20	—	—	.3	—	—	—	—	—	—	—	.3	.1
21	.6	—	.8	—	—	—	—	—	—	—	1.4	.6
22	—	—	—	—	.8	—	—	—	—	—	.8	.3
Total	22.0	43.1	33.2	9.4	5.6	6.0	72.8	16.5	5.8	21.5	235.9	100.0
Percent	9.3	18.3	14.1	4.0	2.4	2.5	30.9	7.0	2.4	9.1	100.0	—

1/ Includes noncommercial species—dogwood, shadbush, black gum, witch hazel, ironwood, sassafras, and butternut—totaling 273 stems under 4 inches d.b.h. and 15.7 stems over 4 inches d.b.h.; and commercial species—white pine, basswood, yellow poplar, black cherry, sugar maple, and yellow birch—totaling 37 stems under 4 inches d.b.h. and 5.8 stems over 4 inches d.b.h.

Table 7.—Average stand data, site I, saw-timber class: volume per acre, by species and diameter

Item	Poor form	Good form	Total		Poor form	Good form	Total	
Species	Cubic feet	Cubic feet	Cubic feet	Percent	Board feet	Board feet	Board feet	Percent
White pine	—	0.5	0.5	—	—	—	—	—
Hemlock	0.6	136.3	136.9	5.8	—	581	581	7.7
White oak	207.0	434.5	641.5	27.2	425	1,499	1,924	25.5
Red oak	98.8	596.0	694.8	29.4	249	2,474	2,723	36.1
Chestnut oak	43.8	18.2	62.0	2.6	55	39	94	1.2
Black oak	3.6	138.5	142.1	6.0	—	627	627	8.3
White ash	21.3	13.6	34.9	1.5	—	65	65	.9
Basswood	—	.2	.2	—	—	—	—	—
Yellow poplar	2.0	55.4	57.4	2.4	—	235	235	3.1
Black cherry	2.2	—	2.2	.1	—	—	—	—
Sugar maple	1.5	—	1.5	.1	—	—	—	—
Red maple	239.8	186.3	426.1	18.1	418	440	858	11.4
Black birch	27.0	26.9	53.9	2.2	—	41	41	.6
Hickory	41.1	52.8	93.9	3.9	198	198	396	5.2
Butternut	.3	—	.3	—	—	—	—	—
Sassafras	3.8	—	3.8	.2	—	—	—	—
Noncommercial1/	11.1	—	11.1	.5	—	—	—	—
Total	703.9	1,659.2	2,363.1	100.0	1,345	6,199	7,544	100.0
D.b.h. (Inches)								
4	17.6	5.2	22.8	1.0	—	—	—	—
5	26.3	9.8	36.1	1.5	—	—	—	—
6	54.9	24.9	79.8	3.4	—	—	—	—
7	68.6	19.8	88.4	3.7	—	—	—	—
8	45.2	45.5	90.7	3.8	—	—	—	—
9	71.5	118.8	190.3	8.1	—	17	17	0.2
10	88.9	58.4	147.3	6.2	—	—	—	—
11	105.7	183.5	289.2	12.2	386	632	1,018	13.5
12	65.3	124.2	189.5	8.0	262	474	736	9.7
13	111.4	159.4	270.8	11.5	454	646	1,100	14.6
14	—	224.2	224.2	9.5	—	988	988	13.1
15	10.3	128.4	138.7	5.9	45	574	619	8.2
16	—	77.7	77.7	3.3	—	368	368	4.9
17	38.2	203.7	241.9	10.2	198	1,040	1,238	16.4
18	—	74.9	74.9	3.2	—	375	375	5.0
20	—	20.8	20.8	.9	—	108	108	1.4
21	—	110.5	110.5	4.7	—	608	608	8.1
22	—	69.5	69.5	2.9	—	369	369	4.9
Total	703.9	1,659.2	2,363.1	100.0	1,345	6,199	7,544	100.0
Percent	29.8	70.2	100.0	—	17.8	82.2	100.0	—

1/ Noncommercial species: dogwood, shadbush, black gum, witch hazel, ironwood.

Table 8.—Average stand data, site II, saw-timber class: number of stems per acre, by species and diameter

D.b.h. (Inches)	Hemlock	White oak	Red oak	Chestnut oak	Black oak	White ash	Red maple	Black birch	Hickory	Misc.1/	Total	Percent
1	—	21	27	24	—	20	237	32	—	351	712	79.9
2	—	—	5	—	—	—	77	—	—	82	164	18.4
3	—	—	—	—	—	—	15	—	—	—	15	1.7
Total	—	21	32	24	—	20	329	32	—	433	891	100.0
Percent	—	2.4	3.6	2.7	—	2.2	36.9	3.6	—	48.6	100.0	—
4	0.3	7.1	2.1	1.6	—	4.0	32.8	0.3	1.0	3.9	53.1	22.9
5	.8	3.9	.8	.3	—	3.0	25.2	.5	1.0	1.6	37.1	16.0
6	4.0	6.6	.8	.8	—	1.0	13.8	.5	1.0	—	28.5	12.3
7	1.6	8.7	2.9	.3	0.5	—	5.0	.5	—	.8	20.3	8.8
8	.8	5.6	1.8	—	.5	1.0	2.9	—	—	.8	13.4	5.8
9	2.4	6.1	.5	.3	.5	1.0	3.4	—	—	—	14.2	6.2
10	.8	4.2	2.9	.3	1.3	—	1.5	.3	—	—	11.3	4.9
11	—	7.1	4.4	—	1.5	1.0	.8	—	—	—	14.8	6.5
12	.3	2.7	3.6	.3	—	—	—	—	.3	—	7.2	3.1
13	—	4.4	4.7	—	.5	—	—	.5	—	—	10.1	4.3
14	—	3.1	4.1	—	.5	—	—	—	—	—	7.7	3.3
15	—	2.1	1.6	—	.5	—	—	—	—	—	4.2	1.8
16	—	2.8	.5	—	—	—	—	—	—	.5	3.8	1.6
18	—	—	1.6	—	—	—	—	—	—	—	1.6	.7
19	—	.3	.5	—	—	—	—	—	—	—	.8	.3
20	—	—	.3	—	—	—	—	—	—	.5	.8	.3
21	—	—	—	—	—	—	—	—	—	.3	.3	.1
23	—	.5	—	—	—	—	—	—	—	—	.5	.2
24	—	—	.5	—	—	1.0	—	—	—	—	1.5	.6
25	—	.3	—	—	—	—	—	—	—	—	.3	.1
26	—	—	.3	—	—	—	—	—	—	—	.3	.1
30	—	.3	—	—	—	—	—	—	—	—	.3	.1
Total	11.0	65.8	33.9	3.9	5.8	12.0	85.4	2.6	3.3	8.4	232.1	100.0
Percent	4.7	28.3	14.6	1.7	2.5	5.2	36.9	1.1	1.4	3.6	100.0	—

1/ Includes noncommercial species—sassafras, dogwood, shadbush, black gum, witch hazel, chestnut—totaling 428 stems under 4 inches d.b.h. and 71 stems over 4 inches d.b.h.; and commercial species—white pine, yellow poplar, yellow birch—totaling 5 stems under 4 inches d.b.h. and 1.3 stems over 4 inches d.b.h.

Table 9.—Average stand data, site II, saw-timber class: volume per acre, by species and diameter

Item	Poor form	Good form	Total		Poor form	Good form	Total	
Species	Cubic feet	Cubic feet	Cubic feet	Percent	Board feet	Board feet	Board feet	Percent
White pine	—	4.8	4.8	0.2	—	—	—	—
Hemlock	1.1	48.5	49.6	2.3	—	87	87	1.4
White oak	147.9	684.9	832.8	40.5	203	2,247	2,450	39.8
Red oak	157.6	514.5	672.1	32.7	555	1,855	2,410	39.1
Chestnut oak	15.4	—	15.4	.7	16	—	16	.2
Black oak	20.3	66.4	86.7	4.2	41	171	212	3.5
White ash	110.6	18.2	128.8	6.3	523	—	523	8.5
Yellow poplar	—	17.8	17.8	.9	—	81	81	1.3
Red maple	143.6	26.9	170.5	8.3	36	—	36	.6
Black birch	17.8	—	17.8	.9	44	—	44	.7
Hickory	6.2	3.2	9.4	.4	18	—	18	.3
Noncommercial1/	52.0	3.2	55.2	2.6	285	—	285	4.6
Total	672.5	1,388.4	2,060.9	100.0	1,721	4,441	6,162	100.0
D.b.h. (Inches)								
4	18.8	1.9	20.7	1.0	—	—	—	—
5	34.5	6.0	40.5	2.0	—	—	—	—
6	56.2	15.5	71.7	3.5	—	—	—	—
7	52.1	37.0	89.1	4.3	—	—	—	—
8	36.1	51.1	87.2	4.2	—	—	—	—
9	61.3	61.9	123.2	6.0	—	43	43	0.7
10	54.8	74.1	128.9	6.3	—	25	25	.4
11	45.6	169.7	215.3	10.4	152	465	617	10.0
12	19.4	108.8	128.2	6.2	61	345	406	6.6
13	21.2	196.7	217.9	10.6	84	697	781	12.7
14	—	201.7	201.7	9.8	—	776	776	12.6
15	—	129.1	129.1	6.3	—	531	531	8.6
16	—	136.9	136.9	6.7	—	577	577	9.4
18	22.7	49.9	72.6	3.5	112	246	358	5.8
19	—	41.9	41.9	2.0	—	201	201	3.3
20	29.8	17.7	47.5	2.3	169	90	259	4.2
21	19.7	—	19.7	.9	116	—	116	1.9
23	—	41.2	41.2	2.0	—	201	201	3.3
24	135.9	—	135.9	6.6	700	—	700	11.4
25	29.8	—	29.8	1.4	151	—	151	2.4
26	34.6	—	34.6	1.7	176	—	176	2.8
30	—	47.3	47.3	2.3	—	244	244	3.9
Total	672.5	1,388.4	2,060.9	100.0	1,721	4,441	6,162	100.0
Percent	32.5	67.5	100.0	—	27.9	72.1	100.0	—

1/ Noncommercial species: sassafras, dogwood, shadbush, black gum, witch hazel.

Table 10.—Average stand data, site I, pole-timber class: number of stems per acre, by species and diameter

D.b.h. (Inches)	White oak	Red oak	Chestnut oak	Black oak	Scarlet oak	White ash	Black cherry	Red maple	Hick-ory	Misc.1/	Total	Per-cent
1	39	27	—	—	—	15	—	242	—	140	463	54.6
2	24	22	—	—	—	—	8	135	—	21	210	24.8
3	16	16	—	—	—	—	—	123	—	20	175	20.6
Total	79	65	—	—	—	15	8	500	—	181	848	100.0
Percent	9.3	7.7	—	—	—	1.8	0.9	59.0	—	21.3	100.0	—
4	24.4	3.2	1.6	—	1.6	1.4	—	40.3	—	2.2	74.7	24.2
5	25.1	6.3	2.2	1.1	2.2	1.4	0.8	32.2	0.7	1.5	73.5	23.8
6	23.9	5.5	1.4	—	—	2.1	—	21.1	.7	1.4	56.1	18.2
7	15.8	3.8	2.0	—	—	—	.7	12.4	—	—	34.7	11.3
8	12.1	.8	—	.6	—	1.4	—	7.1	—	1.4	23.4	7.6
9	12.4	3.3	—	1.2	—	—	—	2.2	—	.6	19.7	6.4
10	6.5	2.1	—	.8	—	—	.8	1.7	—	—	11.9	3.9
11	3.2	1.9	—	1.1	—	—	—	—	—	—	6.2	2.0
12	—	1.4	—	—	—	—	—	—	—	.8	2.2	.7
13	.7	1.9	—	—	—	—	—	—	—	—	2.6	.8
14	.6	.6	—	—	—	—	—	—	—	—	1.2	.4
15	—	1.1	—	—	—	—	—	—	—	—	1.1	.4
19	.8	—	—	—	—	—	—	—	—	—	.8	.3
Total	125.5	31.9	7.2	4.8	3.8	6.3	2.3	117.0	1.4	7.9	308.1	100.0
Percent	40.8	10.3	2.3	1.6	1.2	2.0	0.7	38.1	0.4	2.6	100.0	—

1/ Includes noncommercial species—sassafras, dogwood, shadbush, crataegus, witch hazel, blue beech, ironwood, gray birch and black gum—totaling 181 stems under 4 inches d.b.h. and 2.9 stems over 4 inches d.b.h.; and commercial species—white pine, basswood, black birch, elm and aspen—totaling 5.0 stems over 4 inches d.b.h.

Table 11.—Average stand data, site I, pole-timber class: volume per acre, by species and diameter

Item	Poor form	Good form	Total		Poor form	Good form	Total	
Species	Cubic feet	Cubic feet	Cubic feet	Percent	Board feet	Board feet	Board feet	Percent
White pine	17.7	—	17.7	1.3	79	—	79	5.9
White oak	209.7	420.3	630.0	48.1	45	551	596	44.8
Red oak	20.6	238.6	259.2	19.8	—	601	601	45.2
Chestnut oak	8.7	7.3	16.0	1.2	—	—	—	—
Black oak	11.0	32.7	43.7	3.3	—	54	54	4.1
Scarlet oak	2.5	1.0	3.5	.3	—	—	—	—
White ash	10.9	8.1	19.0	1.4	—	—	—	—
Basswood	.8	—	.8	.1	—	—	—	—
Black cherry	4.3	10.6	14.9	1.1	—	—	—	—
Red maple	183.0	103.1	286.1	21.7	—	—	—	—
Black birch	—	1.7	1.7	.1	—	—	—	—
Hickory	—	3.1	3.1	.2	—	—	—	—
Elm	—	4.3	4.3	.3	—	—	—	—
Black gum	4.6	—	4.6	.3	—	—	—	—
Aspen	6.4	.4	6.8	.5	—	—	—	—
Ironwood	—	2.2	2.2	.2	—	—	—	—
Noncommercial1/	1.3	—	1.3	.1	—	—	—	—
Total	481.5	833.4	1,314.9	100.0	124	1,206	1,330	100.0
D.b.h. (Inches)								
4	32.5	4.7	37.2	2.8	—	—	—	—
5	67.5	32.7	100.2	7.6	—	—	—	—
6	103.4	65.7	169.1	12.9	—	—	—	—
7	82.9	92.8	175.7	13.4	—	—	—	—
8	66.8	96.1	162.9	12.4	—	—	—	—
9	61.9	127.1	189.0	14.4	—	—	—	—
10	35.7	115.0	150.7	11.5	—	—	—	—
11	13.1	86.5	99.6	7.5	45	281	326	24.5
12	17.7	27.2	44.9	3.4	79	97	176	13.2
13	—	62.4	62.4	4.7	—	244	244	18.4
14	—	35.0	35.0	2.7	—	146	146	11.0
15	—	37.8	37.8	2.9	—	165	165	12.4
19	—	50.4	50.4	3.8	—	273	273	20.5
Total	481.5	833.4	1,314.9	100.0	124	1,206	1,330	100.0
Percent	36.6	63.4	100.0	—	9.3	90.7	100.0	—

1/ Noncommercial species: sassafras, dogwood, shadbush, crataegus, witch hazel, and blue beech.

Table 12.—Average stand data, site II, pole-timber class: number of stems per acre, by species and diameter

D.b.h. (Inches)	White oak	Red oak	Chestnut oak	Black oak	Scarlet oak	Bass-wood	Red maple	Black birch	Aspen	Misc.1/	Total	Per-cent
1	85.0	—	—	—	—	—	319.5	—	—	211.6	616.1	61.1
2	32.0	—	—	—	—	—	121.3	—	—	109.2	262.5	26.0
3	53.0	8.0	—	—	—	—	24.0	—	—	45.0	130.0	12.9
Total	170.0	8.0	—	—	—	—	464.8	—	—	365.8	1,008.6	100.0
Percent	16.8	0.8	—	—	—	—	46.1	—	—	36.3	100.0	—
4	24.4	16.3	8.0	0.8	4.8	1.6	25.4	5.6	—	18.4	105.3	29.4
5	28.6	12.1	6.4	1.6	1.6	1.6	22.1	3.2	—	15.3	92.5	25.8
6	21.2	15.3	2.4	—	1.6	—	8.9	.8	4.0	7.3	61.5	17.2
7	12.4	17.7	3.2	.8	—	—	.8	—	1.6	5.3	41.8	11.7
8	4.0	14.7	1.6	.8	—	—	.8	—	.8	.9	23.6	6.6
9	5.1	10.4	—	1.6	—	—	—	—	—	—	17.1	4.8
10	1.9	5.6	—	.8	—	—	—	—	—	—	8.3	2.3
11	—	5.7	—	.8	—	—	—	—	—	—	6.5	1.8
12	—	.8	—	—	—	—	—	—	—	—	.8	.2
13	—	.8	—	—	—	—	—	—	—	—	.8	.2
Total	97.6	99.4	21.6	7.2	8.0	3.2	58.0	9.6	6.4	47.2	358.2	100.0
Percent	27.3	27.7	6.0	2.0	2.2	0.9	16.2	2.7	1.8	13.2	100.0	—

1/ Includes noncommercial species—gray birch, sassafras, shadbush, butternut, chestnut—totaling 365.8 stems under 4 inches d.b.h. and 45.6 stems over 4 inches d.b.h.; and commercial species—black cherry, sugar maple—totaling 1.6 stems over 4 inches d.b.h.

Table 13.—Average stand data, site II, pole-timber class: volume per acre, by species and diameter

Item	Poor form	Good form	Total		Poor form	Good form	Total	
Species	Cubic feet	Cubic feet	Cubic feet	Percent	Board feet	Board feet	Board feet	Percent
White oak	125.3	126.3	251.6	24.6	—	—	—	—
Red oak	118.4	392.5	510.9	49.8	102	234	336	91.0
Chestnut oak	27.2	13.0	40.2	3.9	—	—	—	—
Black oak	5.3	41.2	46.5	4.5	—	33	33	9.0
Scarlet oak	5.0	2.3	7.3	.7	—	—	—	—
Basswood	.3	1.7	2.0	.2	—	—	—	—
Black cherry	3.2	—	3.2	.3	—	—	—	—
Sugar maple	—	.9	.9	.1	—	—	—	—
Red maple	41.6	25.4	67.0	6.5	—	—	—	—
Black birch	4.2	3.6	7.8	.7	—	—	—	—
Gray birch	.9	—	.9	.1	—	—	—	—
Aspen	9.9	14.2	24.1	2.4	—	—	—	—
Sassafras	43.0	15.5	58.5	5.7	—	—	—	—
Butternut	5.6	—	5.6	.5	—	—	—	—
Total	389.9	636.6	1,026.5	100.0	102	267	369	100.0
D.b.h. (Inches)								
4	29.0	13.2	42.2	4.1	—	—	—	—
5	58.2	33.0	91.2	8.9	—	—	—	—
6	106.3	56.3	162.6	15.9	—	—	—	—
7	93.8	96.6	190.4	18.6	—	—	—	—
8	26.7	131.8	158.5	15.4	—	—	—	—
9	43.7	112.0	155.7	15.1	—	—	—	—
10	—	97.5	97.5	9.5	—	—	—	—
11	—	96.2	96.2	9.4	—	267	267	72.4
12	14.6	—	14.6	1.4	43	—	43	11.6
13	17.6	—	17.6	1.7	59	—	59	16.0
Total	389.9	636.6	1,026.5	100.0	102	267	369	100.0
Percent	38.0	62.0	100.0	—	27.6	72.4	100.0	—

Table 14.—Average stand data, site I, seedling-and-sapling class: number of stems per acre, by species and diameter

D.b.h. (Inches)	White oak	Red oak	Chestnut oak	White ash	Black cherry	Sugar maple	Red maple	Black birch	Hick-ory	Aspen	Misc.1/	Total	Per-cent
0.25	48	42	34	22	16	8	246	2	6	4	1,212	1,640	43.7
1	146	58	20	42	70	30	328	8	14	6	642	1,364	36.2
2	114	54	12	12	24	20	172	6	8	4	86	512	13.6
3	48	52	16	6	8	8	68	4	18	—	18	246	6.5
Total	356	206	82	82	118	66	814	20	46	14	1,958	3,762	100.0
Percent	9.5	5.5	2.2	2.2	3.1	1.7	21.6	0.5	1.2	0.4	52.1	100.0	—
4	40	44	8	—	2	4	24	4	—	16	8	150	47.5
5	34	46	12	—	2	2	8	—	—	10	6	120	38.0
6	8	10	—	—	—	—	—	—	—	4	4	26	8.2
7	—	6	6	—	—	—	—	—	—	—	2	14	4.4
8	4	—	2	—	—	—	—	—	—	—	—	6	1.9
Total	86	106	28	—	4	6	32	4	—	30	20	316	100.0
Percent	27.2	33.5	8.9	—	1.3	1.9	10.1	1.3	—	9.5	6.3	100.0	—

1/ Includes noncommercial species—shadbush, witch hazel, crataegus, fire cherr , blue beech, dogwood, black gum, sassafras, and gray birch—totaling 1,932 stems under 4 inches d.b.h. and 2 stems over 4 inches d.b.h.; and commercial species—hemlock, black oak, scarlet oak, basswood, yellow poplar, and yellow birch—totaling 26 stems under 4 inches d.b.h. and 18 stems over 4 inches d.b.h.

Table 15.--Average stand data, site I, seedling-and-sapling class: volume per acre, by species and diameter

Item	Poor form	Good form	Total	
Species	Cubic feet	Cubic feet	Cubic feet	Percent
White oak	41.6	75.4	117.0	29.4
Red oak	46.4	82.8	129.2	32.4
Chestnut oak	42.8	16.2	59.0	14.7
Black oak	1.0	5.0	6.0	1.4
Scarlet oak	15.0	--	15.0	3.7
Basswood	3.0	4.4	7.4	1.8
Black cherry	3.0	--	3.0	.7
Sugar maple	--	4.8	4.8	1.2
Red maple	18.0	6.0	24.0	6.0
Black birch	2.0	--	2.0	.5
Aspen	9.4	23.0	32.4	8.0
Noncommercial[1/]	--	1.0	1.0	.2
Total	182.2	218.6	400.8	100.0
D.b.h. (Inches)				
4	48.8	26.0	74.8	18.7
5	55.4	93.8	149.2	37.2
6	37.4	34.8	72.2	18.0
7	27.0	36.0	63.0	15.7
8	13.6	28.0	41.6	10.4
Total	182.2	218.6	400.8	100.0
Percent	45.5	54.5	100.0	--

Table 16.—Average stand data, site II, seedling-and-sapling class: number of stems per acre, by species and diameter

D.b.h. (Inches)	White pine	White oak	Red oak	Chestnut oak	Black oak	Yellow poplar	Red maple	Yellow birch	Gray birch	Hick-ory	Misc.1/	Total	Per-cent
0.25	—	190	24	—	—	10	490	2	24	2	334	1,076	32.8
1	6	300	100	6	2	4	732	4	32	10	218	1,414	43.0
2	2	216	106	20	—	2	160	—	8	4	38	556	16.9
3	—	134	64	6	6	—	18	—	—	4	8	240	7.3
Total	8	840	294	32	8	16	1,400	6	64	20	598	3,286	100.0
Percent	0.2	25.6	8.9	1.0	0.2	0.5	42.7	0.2	1.9	0.6	18.2	100.0	
4	—	50	14	8	14	—	10	—	—	—	—	96	53.4
5	—	6	14	—	12	2	12	—	—	—	6	52	28.9
6	—	10	8	—	2	—	—	—	—	—	—	20	11.1
7	—	2	2	—	—	—	—	—	—	—	2	6	3.3
8	—	4	2	—	—	—	—	—	—	—	—	6	3.3
Total	—	72	40	8	28	2	22	—	—	—	8	180	100.0
Percent	—	40.1	22.2	4.4	15.6	1.1	12.2	—	—	—	4.4	100.0	—

1/ Includes noncommercial species—shadbush, dogwood, scrub oak, crataegus, sassafras, chestnut—totaling 582 stems under 4 inches d.b.h. and 4 stems over 4 inches d.b.h.; and commercial species—scarlet oak, black birch, aspen—totaling 16 stems under 4 inches d.b.h. and 4 stems over 4 inches d.b.h.

Table 17.--Average stand data, site II, seedling-and-sapling class: volume per acre, by species and diameter

Item	Poor form	Good form	Total	
Species	Cubic feet	Cubic feet	Cubic feet	Percent
White oak	54.6	36.0	90.6	43.4
Red oak	32.2	28.4	60.6	29.0
Chestnut oak	2.4	.8	3.2	1.5
Black oak	6.0	15.4	21.4	10.3
Yellow poplar	--	2.2	2.2	1.1
Red maple	17.2	--	17.2	8.2
Black birch	--	8.0	8.0	3.8
Aspen	--	2.0	2.0	1.0
Sassafras	--	3.6	3.6	1.7
Total	112.4	96.4	208.8	100.0
D.b.h. (Inches)				
4	28.0	10.4	38.4	18.4
5	31.8	18.6	50.4	24.1
6	16.2	36.8	53.0	25.4
7	9.4	17.0	26.4	12.6
8	27.0	13.6	40.6	19.5
Total	112.4	96.4	208.8	100.0
Percent	53.8	46.2	100.0	--